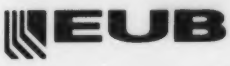
Prairie Oil and Gas:

A Lighter Footprint



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Prairie Oil and Gas:
A Lighter Footprint

By Heather M. Sinton

This publication is intended to provide government, industry and the general public with up-to-date information about best practices to reduce the impacts of oil and gas activities on prairie and parkland landscapes. The opinions, findings and recommendations expressed in this book are those of the author and do not necessarily reflect the views of government, industry, consultants or academics. Mention of trade names, commercial products or suppliers does not constitute endorsement, or recommendation for use.

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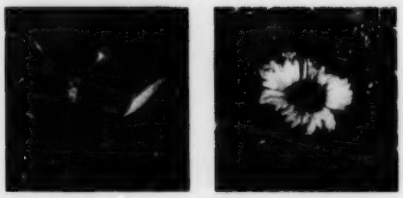

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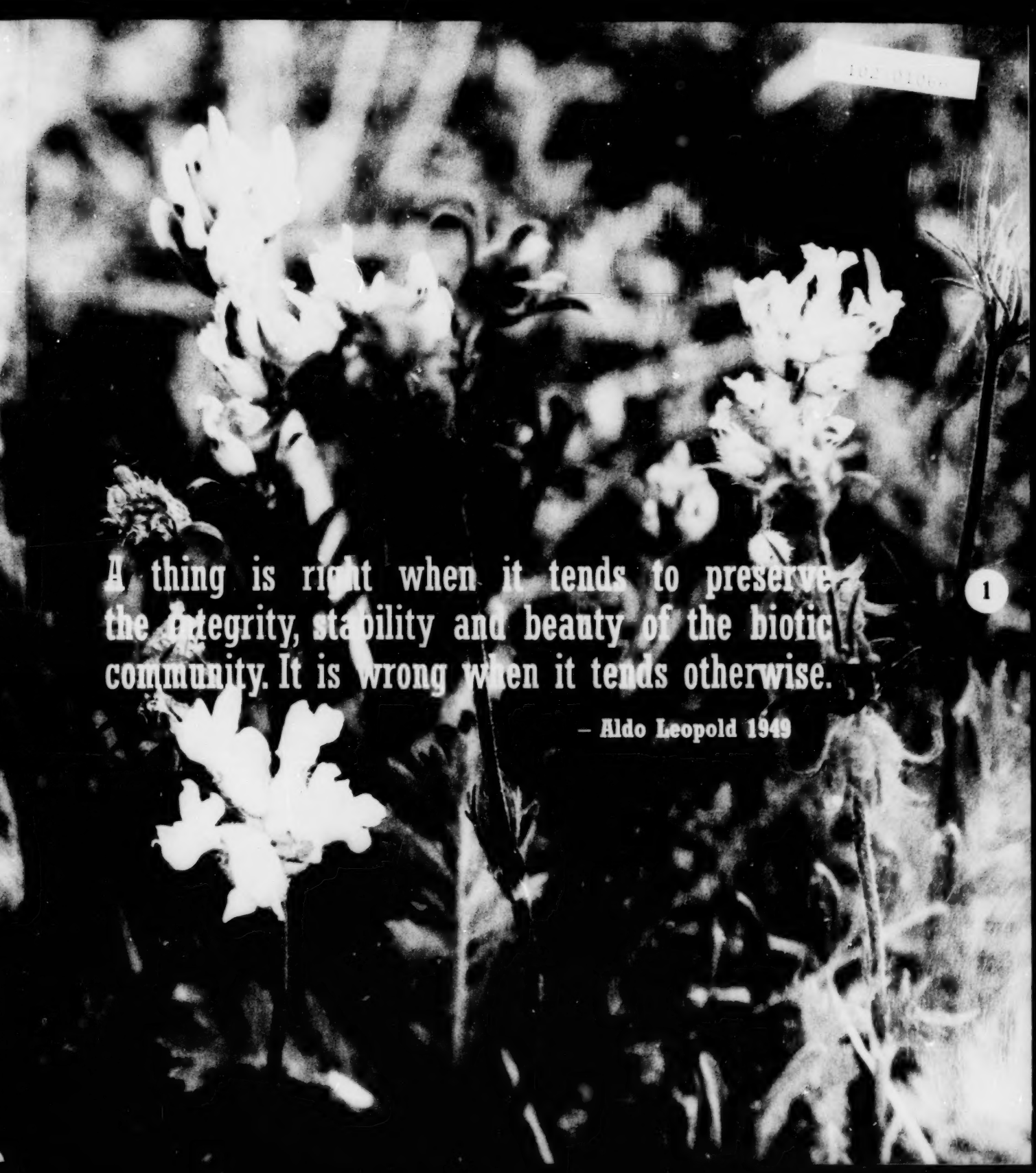

A thing is right when it tends to preserve
the integrity, stability and beauty of the biotic
community. It is wrong when it tends otherwise.
– Aldo Leopold 1949

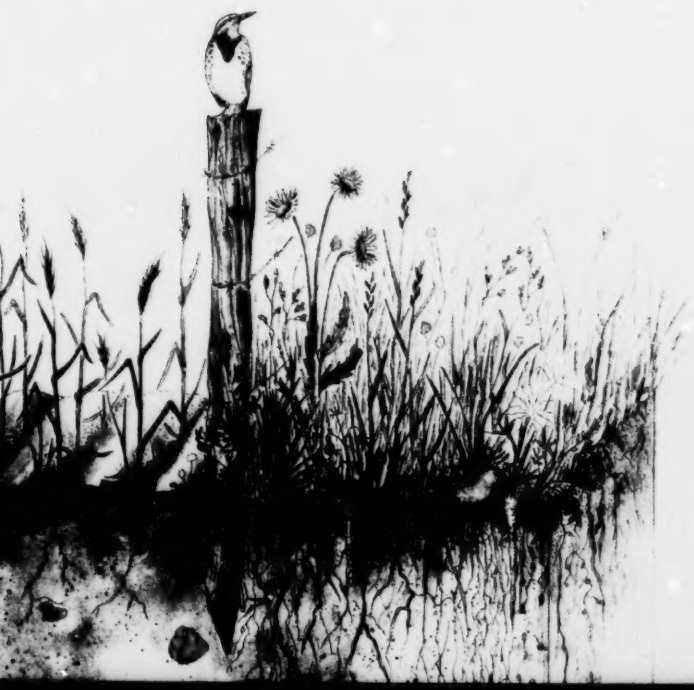
Introduction

This publication is intended to provide information about best management practices for oil and gas activity in native prairie and parkland areas. However, many of the principles and practices should be applied to other activities proposed for these landscapes.

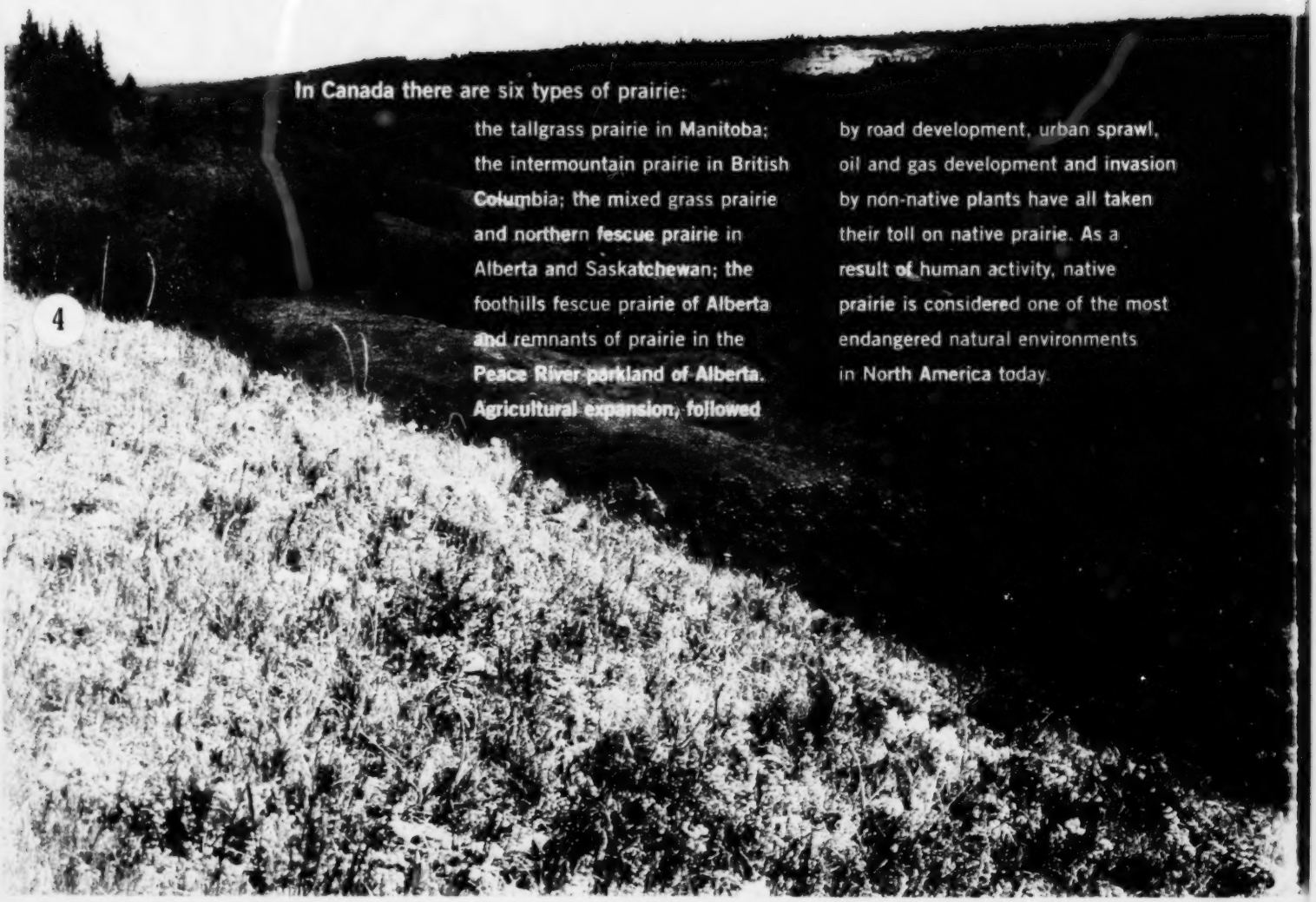
Native prairie is an area of unbroken or recovered grassland or parkland dominated by native plant and wildlife species. Native prairie and parkland landscapes are diverse and may include riparian forests along rivers, potholes and wetlands, badlands, shrub-dominated communities and sandhill complexes.

In one human lifetime, the prairies have passed from wilderness to become the most altered habitat in this country...

– Adrian Forsyth 1983



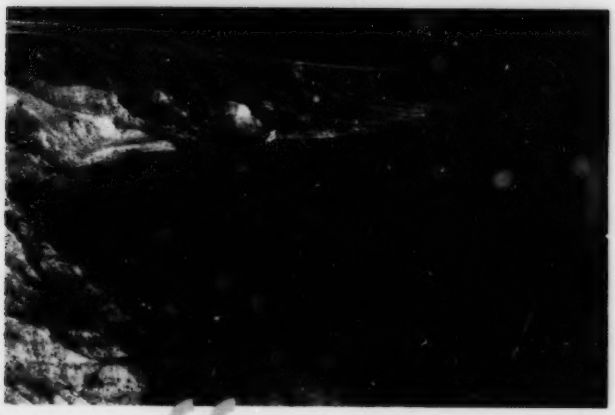
Prairie once covered vast areas of Canada's prairie provinces. With the arrival of the railroad in Manitoba in the late 1800s, prairie landscapes were forever altered in Western Canada. The rich soils, developed under the diverse prairie vegetation were ideal for growing crops.



In Canada there are six types of prairie: the tallgrass prairie in Manitoba; the intermountain prairie in British Columbia; the mixed grass prairie and northern fescue prairie in Alberta and Saskatchewan; the foothills fescue prairie of Alberta and remnants of prairie in the Peace River parkland of Alberta. Agricultural expansion, followed by road development, urban sprawl, oil and gas development and invasion by non-native plants have all taken their toll on native prairie. As a result of human activity, native prairie is considered one of the most endangered natural environments in North America today.

Prairie is recognized today for its significant ecological, cultural and aesthetic values as well as economic benefits.

Multiple uses, including: grazing, wildlife habitat, recreational use, and industrial and commercial development need to be sustained. Prairie is vital to soil formation, water quality and watershed protection, as well as the conservation of a huge diversity of irreplaceable plant and animal life. Prairie landscapes also have cultural and historical significance and great natural beauty.

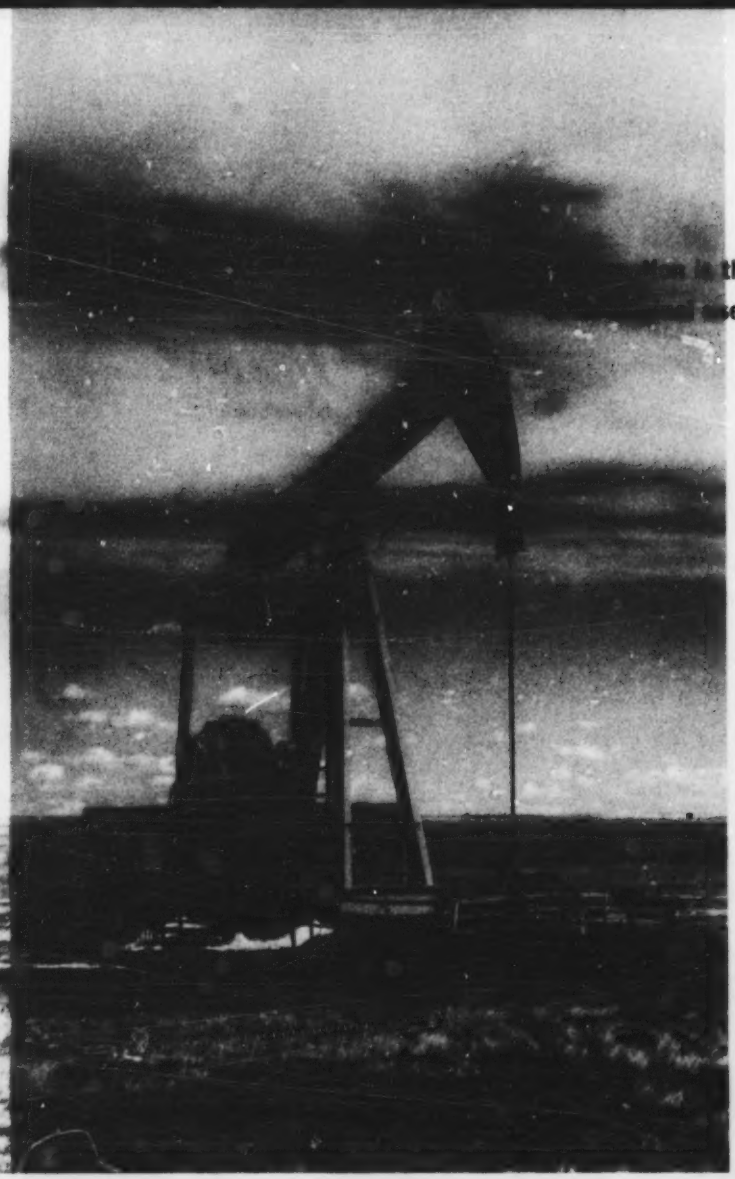


As a result of human activity, native prairie is considered one of the most endangered natural environments in North America today.

Impacts of Oil and Gas Development on Prairie

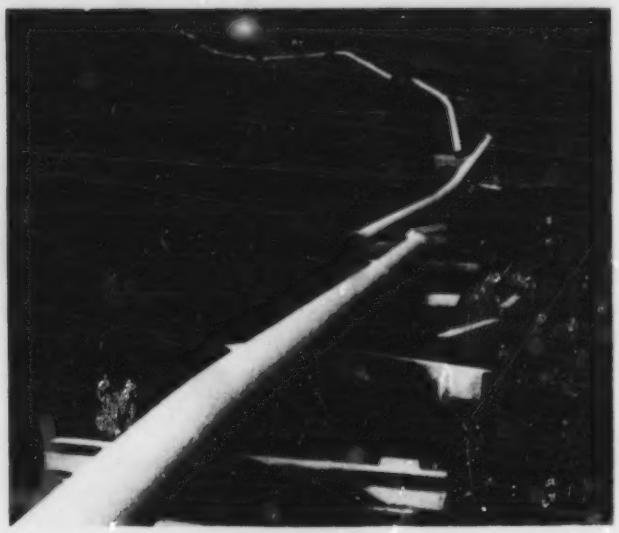
Agricultural settlement has certainly had the biggest impact on prairies, but in recent years, oil and gas development has impacted remaining prairie landscapes significantly. By the end of 2000, more than 260,000 oil and gas wells had been drilled in Alberta. Some of the impacts of oil and gas activity include:

- fragmentation of prairie into increasingly smaller areas of undisturbed land
- introduction of invasive non-native plants
- disturbance to landscapes, soils and native vegetation
- disturbance of heritage resources
- disturbance of wildlife
- potential for spills of oil, gas, diesel or salty produced water



Goal is the return of disturbed land to natural use or another productive use.

Early disturbances on prairie were not reclaimed. There was a movement in the 1950s to clean up any mess made, after the fact, which often resulted in difficulties during reclamation. Today, there is a significant amount of planning prior to disturbance to minimize the impact, followed by reclamation at the end of an activity. Reclamation practices are always being refined and improved.



Today, the goal of reclamation on natural landscapes, such as prairie, is to "set the stage for eventual recovery", recognizing that time and natural processes are essential for completing the healing process.

Techniques for Minimizing Disturbance

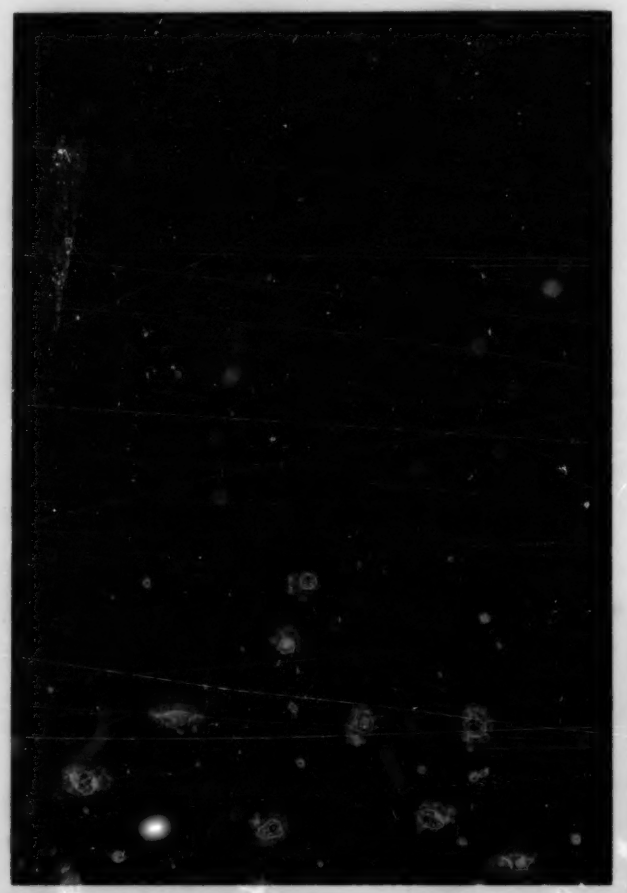
8

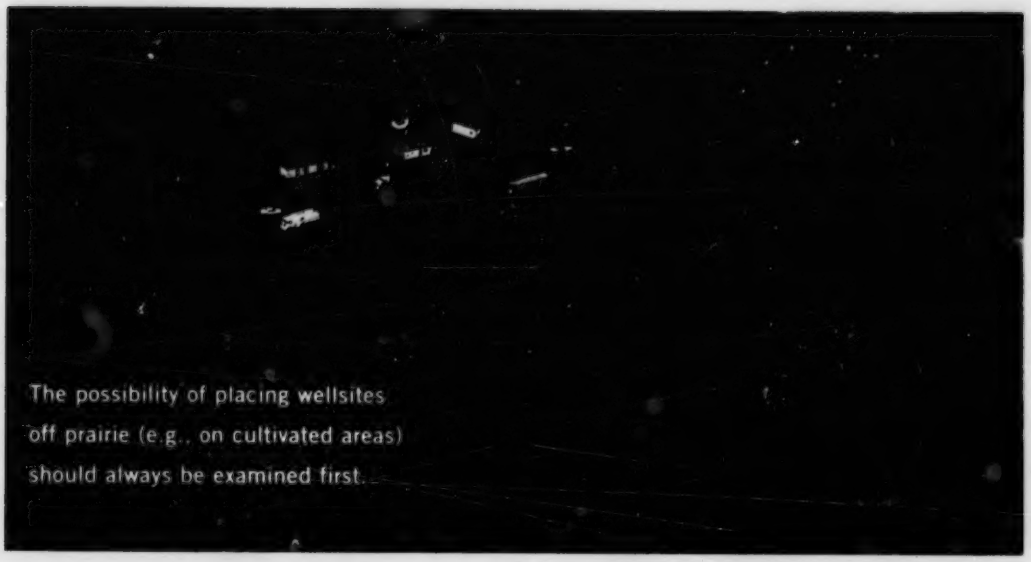
Minimizing disturbance involves reducing the impact of an activity by making the "footprint" of the activity on the land smaller, avoiding sensitive areas completely and by timing the activity for periods when prairie soils, vegetation and wildlife are less at risk.

Options for avoiding sensitive areas include finding alternate locations for or re-routing the project, using alternative construction techniques or times of construction.

Avoidance

Some particularly sensitive prairie landscapes and features that should be avoided include: waterbodies, wetlands, coulees, river valleys, dry lakebeds, rare landforms, plants or plant communities, listed wildlife species and important wildlife areas, very rough topography and erodible soils, and archaeological sites. Options for avoiding sensitive areas include: finding alternate locations for or re-routing the project, using alternative construction techniques. Adjusting timing of construction or reclamation activities to less sensitive periods during the year is common practice to avoid breeding or spawning times for wildlife or fish, and to minimize the disturbance to native vegetation.





The possibility of placing wellsites off prairie (e.g., on cultivated areas) should always be examined first.

Boring of watercourse crossings has also reduced disturbance to many rivers and streams within the prairie landscape.

Directional Drilling

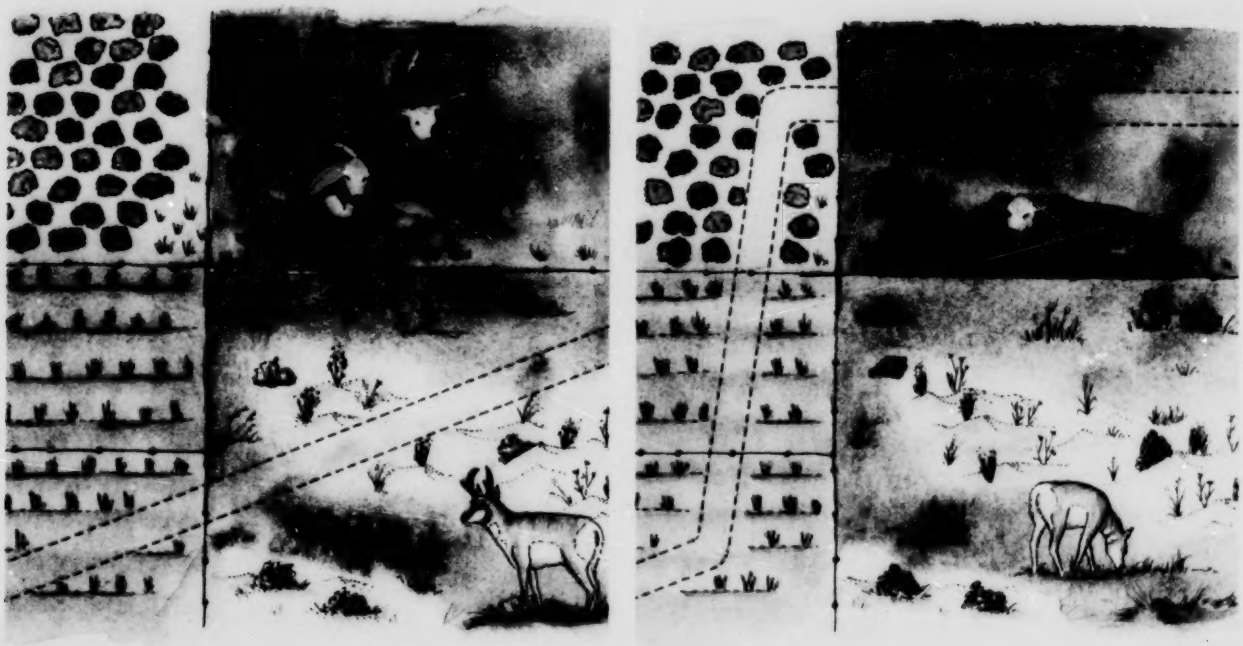
12

In recent years, directional drilling of oil and gas wells has made it possible to move the surface location of a wellsite and still reach the downhole target. Distances for directional drills are dependent on the geology in the area and technological constraints.

Directional drilling has also made it possible to put several wells in one location or pad and drill in different directions. This avoids the "spider-web" of pipelines and access roads connecting wellsites.

"A holistic or "cradle to grave" approach ensures that care taken during one phase of development is not undone at another stage."

Minor routing adjustments are often possible on pipelines or the right-of-way can sometimes be narrowed to avoid sensitive features.



Before **After**

Careful Pre-Planning

Successful reclamation depends on careful project planning. For any proposed development, there needs to be a well thought out plan that is put in place well ahead of time. An important component of planning is communication with landowners, land managers and appropriate regulatory authorities. Landowners and land managers can often provide important information about the land that may not be available elsewhere.

There is increasing emphasis being placed on consideration of the effects of all projects and activities in an area (cumulative effects). The ability of natural landscapes to support oil and gas activities on a sustainable basis hinges on the timing and intensity of development. Best management practices and innovative procedures can go a long way toward managing impacts. On some sites, however, the level and duration of activities may be such that phasing and careful timing of field operations may be necessary. This can avoid fragmentation and cumulative impacts that may have more permanent effects on the health of the prairie landscape.

"Existing activities should be examined and at a minimum, new projects integrated with them to reduce the overall level of disturbance."

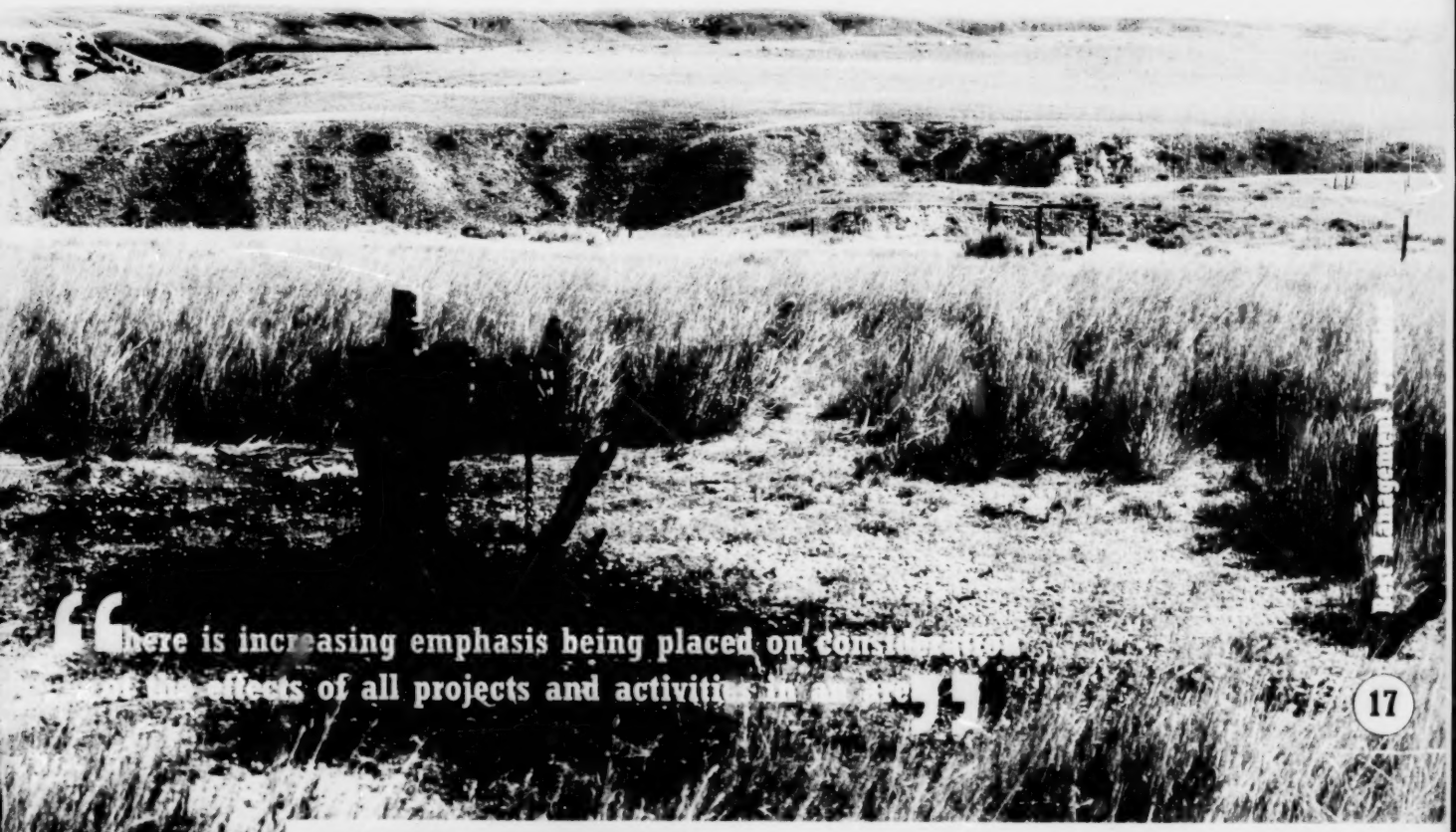
Mamawi Lake Region, Alberta – An example of energy sector development; squares are wellsites, lines are pipelines and access roads

1949 **1991** **1998**

Best Management Practices

16

Minimizing disturbance is more than just reducing the area of impact of an activity. It also means using the best available techniques and practices to reduce the overall footprint of activity during all phases of construction, operation, reclamation and abandonment. This holistic or "cradle to grave" approach ensures that care taken during one phase of development is not undone at another stage.

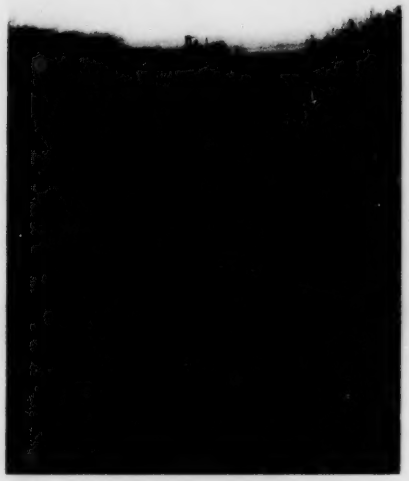


"There is increasing emphasis being placed on consi... the effects of all projects and activiti... the..."

Timing

the extent of environmental impacts
nd gas exploration and development.

The best times for entry are during dry or frozen soil conditions. Care needs to be taken to accommodate landowner/occupant use of the land and to minimize disruption of grazing activities.



Shut down criteria

It is vitally important to have clear shut-down criteria in place for inclement weather (e.g., wet conditions, high winds). All construction personnel should be trained to recognize conditions under which operations should cease (e.g., rutting of soils, excessive dust). For more guidance, see Alberta Environment's Information Letter (IL) 98-4.

Fall construction

Fall construction is better for achieving revegetation success, particularly if natural recovery (no seeding) of the area is planned. Salvaging soils (particularly the top few centimetres) following seed drop, results in better native plant re-establishment on the reclaimed area.

Wildlife constraints

It is important to consult with local wildlife biologists to determine the best times to construct without undue disturbance to wildlife populations. Usually construction during breeding times is restricted, as is watercourse construction during fish spawning periods. Care must be taken to avoid siltation of watercourses.

Rare Plant Survey

A rare plant species is any native plant that occurs in very low numbers or in limited areas.

When planning a project, it is important to call the Alberta Natural Heritage Information Centre (ANHIC: (780) 427-5209) to check whether any rare plants have been sighted in the area. Plant surveys should be undertaken when information for an area is lacking. The Alberta Native Plant Council has published *Guidelines for Rare Plant Surveys*, available on their website: www.anpc.ab.ca to help planners.

Contingency Plans

It is also important to have contingency plans when faced with sudden, unplanned constraints or challenges.

Given limitations of weather, availability of equipment and experienced labour, well-planned maximum disturbance that salvages soils may be a better alternative than poorly implemented minimal disturbance that results in extensive damage to both vegetation and soils (e.g., rutting).

There needs to be a well thought out construction plan.

The plan must be in place well ahead of time to enable project personnel to respond to last minute changes. Every effort should be made to use equipment that is suited to the size of the job and that results in the least possible impact.

Specialized Equipment

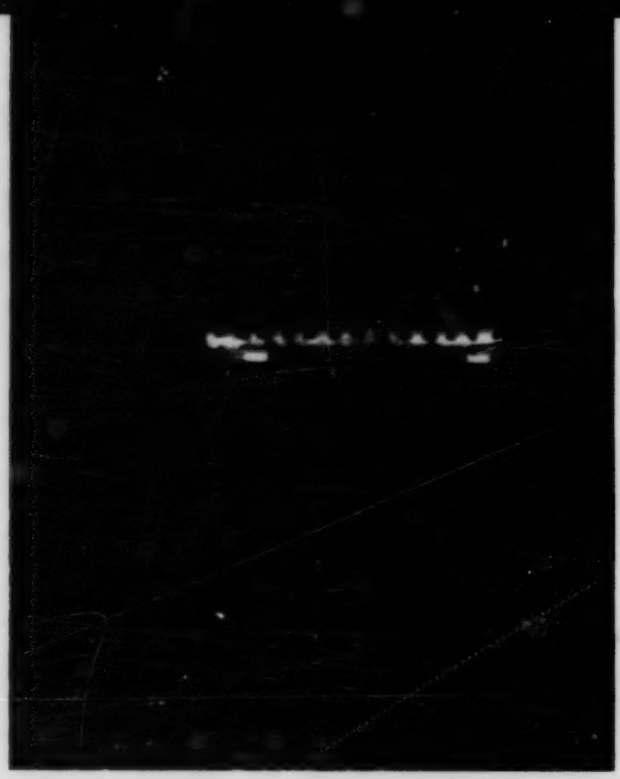
Industry has produced some innovative equipment that helps to conserve prairie soil and vegetation during construction and reclamation. Often simple modifications to existing equipment can make a significant difference to the extent of disturbance.

Prairie protector blades

Prairie protectors are flexible plastic blades that can be attached to cat or backhoe blades to reduce scalping of prairie sod during soil replacement.

Frozen topsoil cutter

One of the most difficult construction problems is salvaging the right amount of topsoil under frozen conditions. The frozen topsoil cutter attaches to the ripper bar of a cat and can control the depth of soil stripped.

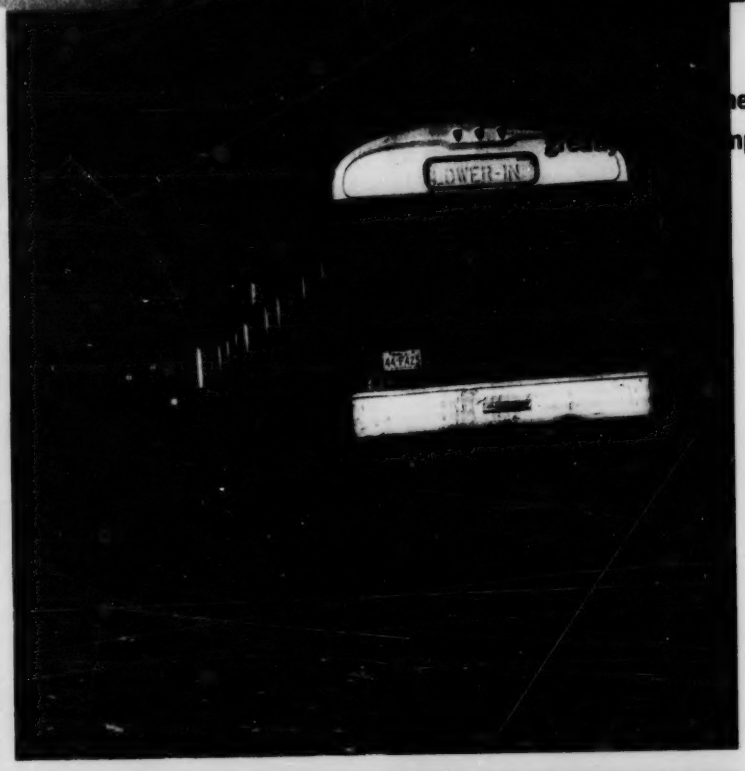


Kinsella accuroller

This specialized seeder allows native seed to be broadcast close to ground level and rolled into the soil in a single operation. It leaves indentations on the soil surface which create "safe sites" for seed to germinate.

Sod cutters

Sometimes it is possible to cut the prairie sod, store it during the construction phase of a project and replace it afterwards. This requires special equipment that can cut sod at a 10 to 15 centimetre depth. Sod cutters used in the lawn industry do not work well as they do not cut the sod deep enough. Asphalt cutters attached to a backhoe have been used successfully.



ent of traffic on construction and reclamation sites can npacts of vehicles and equipment on the prairie sod.

Use of multiple passenger vehicles

The use of buses to bring in construction personnel to larger projects can reduce the number of pickup trucks driving over the prairie.

Use of All Terrain Vehicles (ATVs)

ATVs, instead of pickup trucks, can be used by inspection personnel to reduce disturbance.

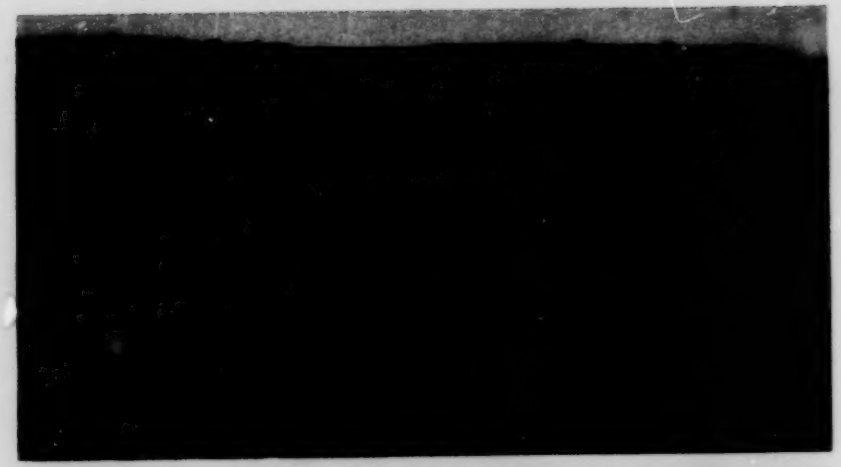
Speed limits

Enforcing speed limits on undeveloped access trails and on pipeline rights-of-way can improve safety and save valuable prairie resources.

Designated access points

Clear marking of access points to the construction site can limit disturbance to one or several (in the case of large projects) areas, which can then be properly reclaimed following construction operations.

Practices

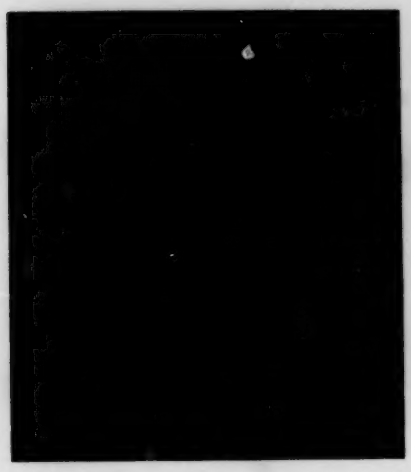


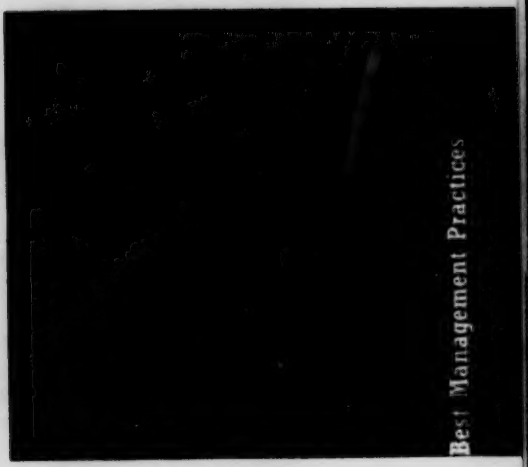
In dry, flat prairie environments, wind erosion is an ever-present hazard on disturbed areas.

In moister prairie areas where hills are a dominant part of the landscape, water erosion is a greater concern. In both cases, it is extremely important to protect exposed soils, and prevent their loss.

Application of tackifier

Tackifiers are usually non-toxic mixes of wood fibre and "glue" that are combined with water and sprayed on topsoil piles during construction. Tackifiers can prevent wind erosion for a few days through several weeks, depending on the product.





Cover cropping using annuals

Cover crops (e.g., durum wheat, flax) with quick germination and emergence, are often sown on sites where natural recovery (no seeding) is used to provide some protection from soil erosion. In dry environments, cover crops should be seeded sparingly (less than half the normal agricultural rate) so they don't compete too much with native plants for light and water. It is important to use crops that are less attractive to livestock and to keep livestock off the reclaimed area while the plants are young and tender.

Use of straw bales

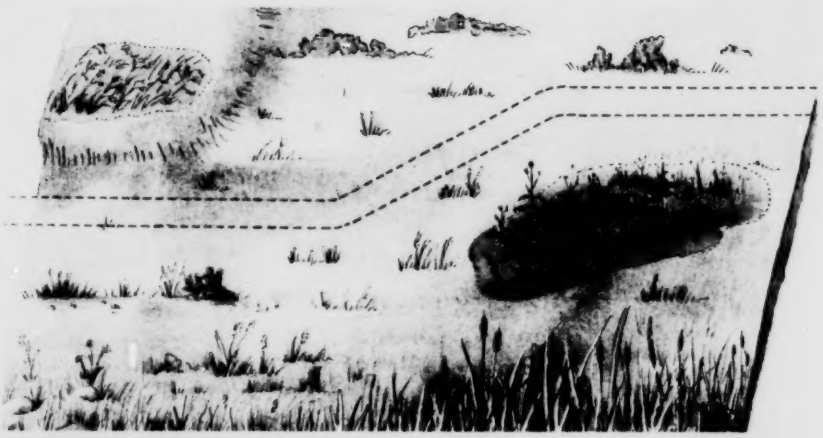
Straw bales are useful for wind erosion control when they are placed in a grid pattern. Straw bales should not be used where there is flowing water. Water tends to undercut below the bales or go around the ends. Straw bales must be weed free.

Erosion Control Products

Matting of various weights is effective in preventing erosion on steep slopes and along watercourses. It is important to choose the right product for the job, and to ensure that there is close contact of the material with the ground. Some products are made for lining channels (i.e., products that are thick and stiff), while others are made for protecting soil on slopes (i.e., products like coir or jute matting that are thinner and more flexible).

Weed Prevention

There are a number of good practices that can prevent the introduction of problem weeds during construction, operation and reclamation of oil and gas facilities.



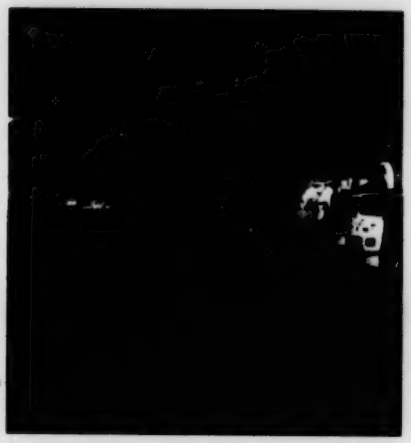
Importance of pre-construction weed surveys

Conducting a weed survey prior to construction is a good way to avoid bringing unwanted plants into a prairie site. Landowners should be given a copy of the weed survey. Contaminated areas can be avoided during, or treated prior to, construction.

Importance of clean storage areas

Check that storage yards that materials are coming from are not contaminated with weeds. Pipeyards, for example, are an often overlooked source of weed problems.

"There are a number of good practices that can prevent the introduction of problem weeds."



Importance of clean equipment

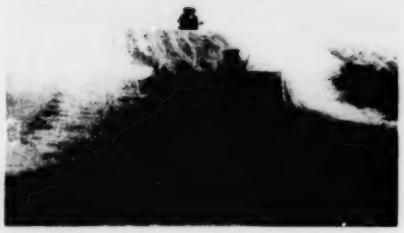
All equipment and materials used on prairie reclamation sites must be free of problem weeds. Construction and reclamation equipment should be cleaned before entering prairie areas. Steam or pressure cleaning is effective if done carefully. Pick-up trucks and quads should also be cleaned. Clean equipment and materials in a visible area so that weeds that do come up can be easily controlled.

Using clean materials

If topsoil is required, make sure that it is free of weeds of concern. Try to get it from the landowner and do not haul long distances. It is also important to check local municipal regulations. If suitable topsoil is unavailable, the soil on the site can be improved by using appropriate amendments and cropping practices.

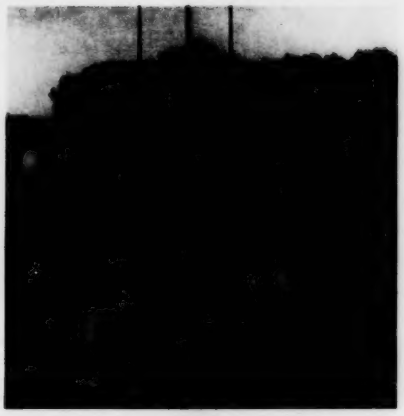
Commercial compost is usually certified weed free. Use only manure from cattle fed hay and grain from the same farm in order to reduce the chance of introducing new weeds. Practice green manure plow-downs and forage-dominated rotations to improve soil tilth and productivity.

Weed Prevention continued...



Straw crimping

Straw crimping is one way of preventing erosion on prairie reclamation sites. It involves pressing wheat or flax straw into the soil in a wave-like pattern using special equipment. It is very important to use weed-free straw for this. Straw crimping may be banned in some jurisdictions due to weed introduction concerns. Inspecting the source fields prior to purchase can prevent problems. Another option is to use the landowner's own crop residue or to ask the landowner who they would prefer to have the straw purchased from. For big projects, e.g., pipelines, it is feasible to have material custom grown.



Controlling weeds

Mowing is preferred to spraying for weed control on prairie sites. Spraying, particularly for broad-leaved weeds, can damage native forbs (flowers) that are re-establishing on reclaimed areas. When mowing to control weeds, it is important to do it prior to flowering. Otherwise, mowing can spread the weed seeds. When mowing areas seeded to native species, mow high enough (15 cm) to avoid damaging establishing native seedlings.

20 20

Report of Seed Analysis

The only way to ensure that seed is free of problem weed and invasive non-native plant species (e.g., smooth brome) is to ask the seed supplier for a Seed Analysis Certificate for each seed lot ordered.

The sampling must be done for each revegetation species used, prior to mixing. The certificates need to be examined by a qualified individual to determine whether any plant species of concern are present. Check with regulatory personnel including agriculture fieldmen and land management agencies to identify plants of concern in a particular area.

Prohibited Noxious

Primary Noxious

Total Primary 0.

Secondary Noxious

Total Noxious 0.

ure Seed	50.2	%	Pure Living Seed		
ther Crop Seeds	0.0	%	Multiple Seed Units	0.0%	Hard Seeds
eed Seeds	0.1	%	Ergot	0.0%	Germination incl. Hard Seeds
ert Matter	47.7	%	THE SAMPLE GRADES:		

EMARKS:

HE FOLLOWING DATA PROVIDED IS FOR INFORMATION PURPOSES ONLY
% PURE SEED, GERMINATION, PURITY REQUESTED
10. TOTAL GRAMS ANALYSED
ANALYSED ACCORDING TO TABLE XII -CANADA SEEDS ACT
PURITY MEETS MINIMUM CANADIAN STANDARDS.
Sample analyzed according to Canadian methods and procedures for testing seed (CFIA)

SENIOR MEMBER OF

Minimizing the Impacts of Geophysical (Seismic) Activity

32

Minimizing the impacts of geophysical (seismic) activity on the prairie involves use of existing trails whenever possible and when ground conditions are either dry or frozen. Access routes must observe suitable setback distances (e.g., from coulees) and timing restrictions associated with sensitive wildlife and features. Vehicles and equipment with the least potential for surface disturbance should be selected.

Seismic activity through areas that require clearing (i.e., trees and shrubs) should be minimized as much as possible and access across wet areas should be avoided. If clearing is necessary, straight lines should be avoided to reduce visual impact.

Low impact seismic

When it is necessary to conduct seismic activity through coulees or low areas with cottonwoods, the use of hand-cut lines and light-weight equipment can minimize the damage to the landscape and vegetation.

Clean up debris

Care needs to be taken to replace cuttings in shot holes and to remove any debris resulting from the activity (e.g., survey tape). Seeding following seismic activities is usually not required due to minimal soil disturbance.

Minimizing the Impacts of Drilling Activity

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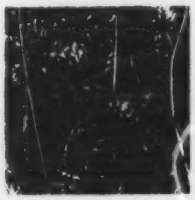
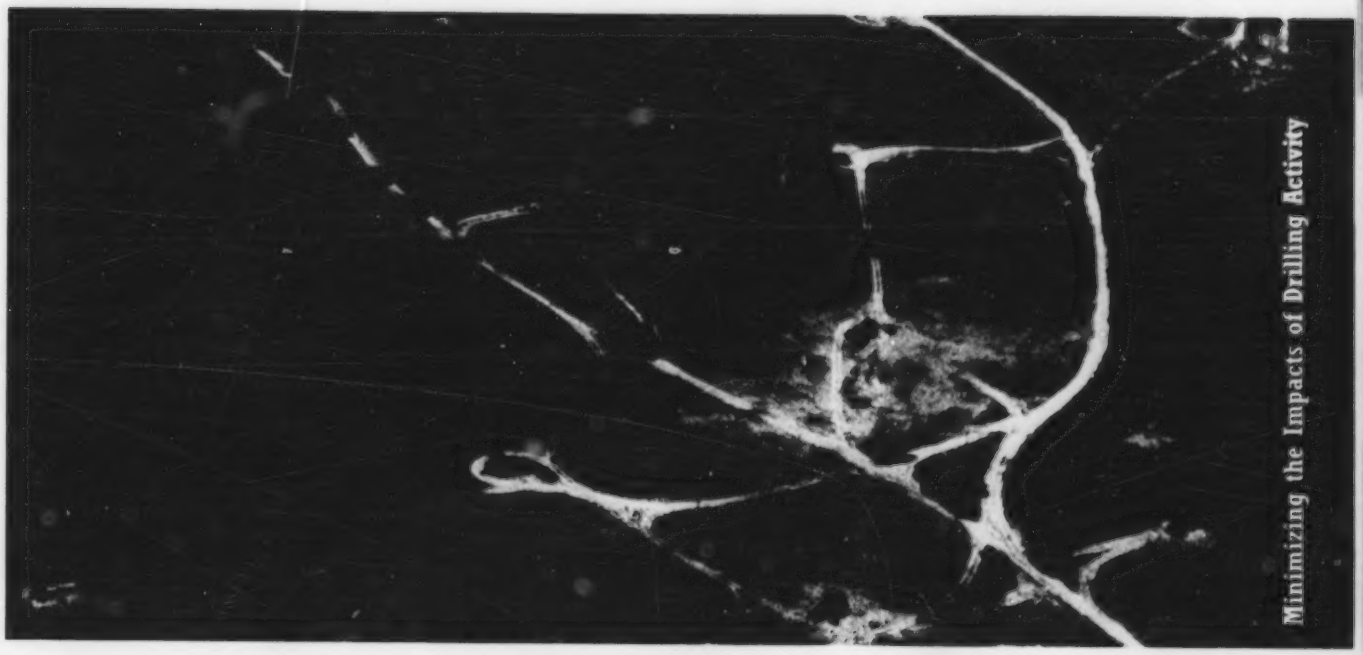


Careful planning, construction and reclamation techniques are key to reducing the impacts of oil and gas drilling on prairie and parkland.



Pre-planning developments to minimize environmental impact

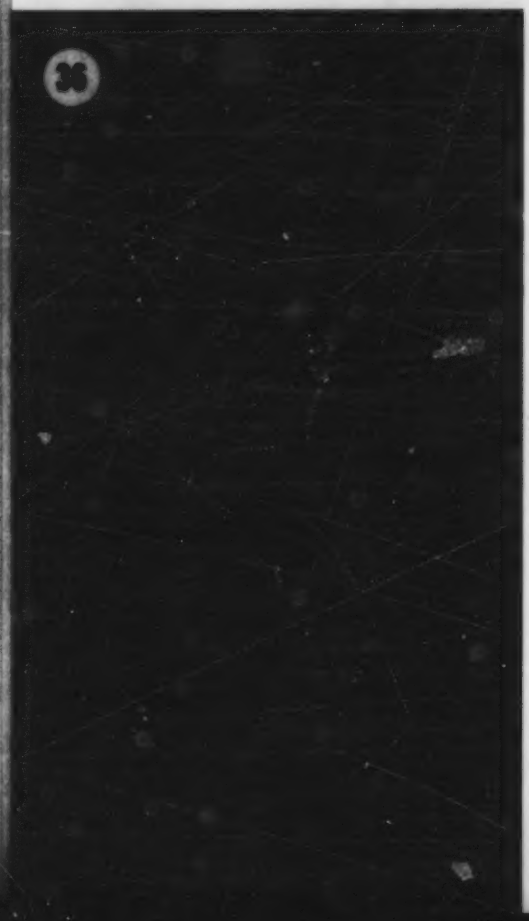
When planning the development of an oil or gas field, it is often possible to minimize environmental impacts to prairie by directionally drilling a number of wells from one location (pad) and by placing pipelines and electric transmission lines along access roads. Any previously disturbed sites, or areas of tame pasture or cultivation should be used first.

Avoid riparian areas and dry lakebeds

More sensitive features such as riparian areas along streams or dry lakebeds should be avoided. It is often possible to locate the wellsite in a less sensitive area and directionally drill to the target zone.

Construction

Careful construction can reap high benefits [illegible] reduced footprint on the landscape and a lower cost of construction.

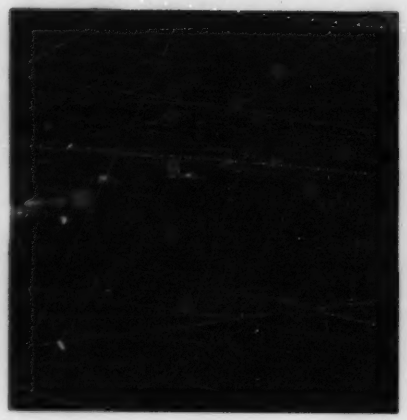


Minimum disturbance wellsites

Shallow gas wells can usually be drilled within a 24 hour period. Often the small drilling rig can be placed right on the prairie vegetation, without stripping soils. Tanks are used to contain the drilling muds. The result is a very small "footprint" which heals very quickly, often without reseeding. Oil wells take longer to drill, therefore, there is a greater risk of running into bad weather. Rain or thaw conditions can result in rutting of soils. Due to this risk and the increased risk of contamination, it is often wise to strip soils back on oil well leases. It is still possible to reduce the area that has to be stripped, reducing the overall disturbance to prairie vegetation and soils.

Cut and fill

Wellsites should be sited as often as possible on level ground. The need for cut and fill at wellsites can be reduced through careful site selection, altering the size and shape of pad sites, and the use of self-levelling rigs. When cut and fill is required in hilly areas, care must be taken to stabilize slopes. Contours must be blended into the surrounding landscape during reclamation.



Drilling fluid disposal

Drilling fluids used to drill prairie wells are water-based. Companies should recycle drilling fluids to minimize water requirements in the dry prairie environment. Often disposal problems associated with drilling fluids are related to salinity or sodicity from make-up water. Testing of make-up water sources can minimize disposal problems later on.

Fluids associated with drilling systems should be managed to prevent contamination to surface water, groundwater, or soil resources. The use of portable flare pits, berms, clay pads, catchment pans under rigs, and filter fabric are options that can be considered to reduce potential impacts. Only above ground sumps (tanks) or remote sumps (off native prairie) are allowed on native prairie and parkland areas on public lands and in the Special Areas except where full site stripping has occurred. Disposal of waste by landspraying while drilling (LWD) is limited to fresh water-based gel drilling mud systems. Where allowed, LWD should be targeted for spraying on cultivated land first, then tame hay-land, and finally native prairie as a last resort.

Soil handling

Topsoil contains valuable organic matter, seeds and rhizomes and it is important to salvage it carefully and protect it from erosion and contamination during storage. Topsoil must be stripped separately from subsoil (two lift) and the piles separated. If natural recovery (no seeding) is planned for revegetation, consideration should also be given to salvaging the sod layer (seed bank) separate from the topsoil layer. Soil resources must be protected from wind and water erosion during the construction period, and throughout the production period.

Production

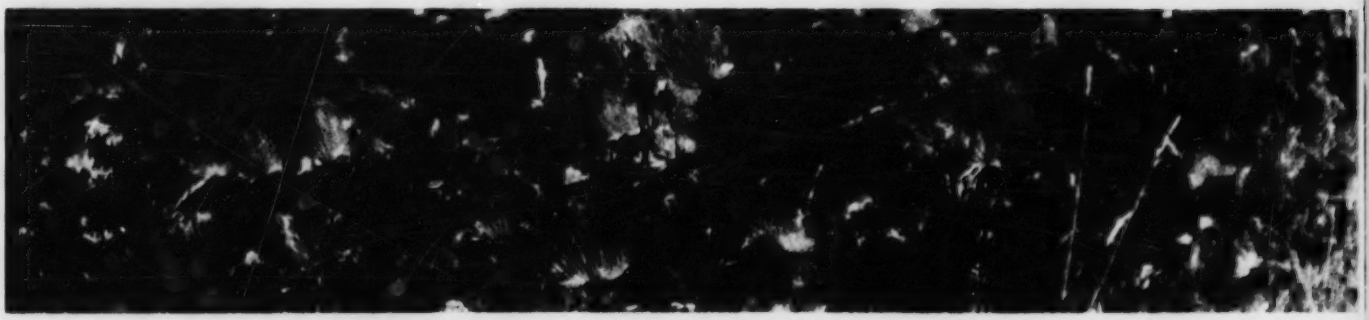
Access during the drilling phase should use existing trails or temporary access across the prairie. Timing of activities (e.g., well servicing) to ensure stable or frozen ground conditions is essential. Access routes must observe suitable setback distance and timing restrictions associated with sensitive wildlife and features (e.g., coulee complex) and avoid historical resources.

Access routes may need to be upgraded once production begins due to the impacts of regular traffic. Operators should monitor for impacts such as erosion and rutting. If impacts are noted or heavy traffic is anticipated, access can be upgraded as a means of environmental protection. Planners need to carefully consider the type of access road that is required and not over-build. Where the development of new access is required, it should be carefully planned to avoid sensitive areas. Non-permanent access to remote wells should be considered, especially in sensitive areas.

Interim reclamation

Final reclamation and seeding should be done on areas of the lease that will not be redisturbed after abandonment of the well. Topsoil held back for future reclamation should be spread to a depth of 30 to 50 centimetres and reseeded. This shallow depth keeps the seeds and microbes in the stored soil alive. The soil should be placed where it can be easily recovered and the location carefully recorded and kept on file with the wellsite history. A simple sketch on the survey drawing is effective.

Timing of activities (e.g., well servicing) to ensure stable or frozen ground conditions is essential.



Minimizing the Impacts of Pipelining

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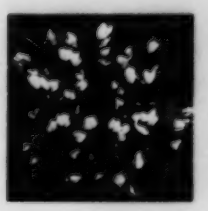


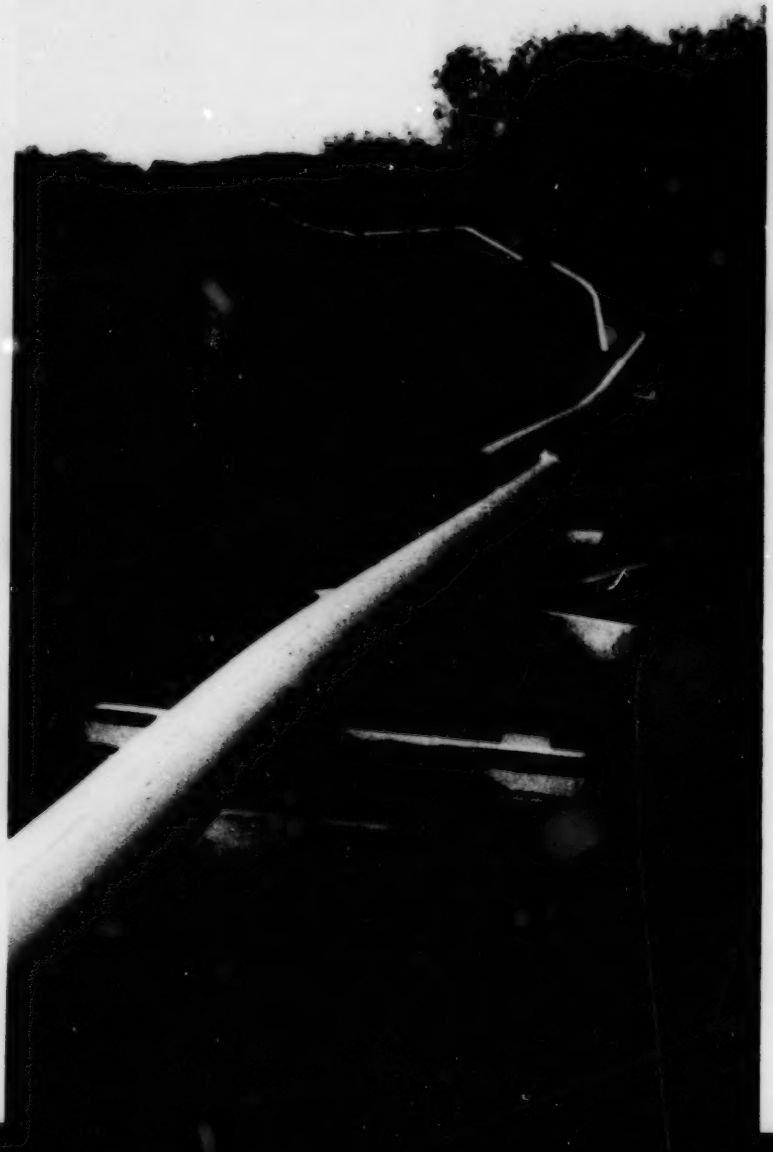
Environmental impacts associated with pipelines are usually confined to a short period of time during surveying, construction and reclamation, during maintenance or repair periods and again at abandonment (if the pipe is removed from the ground).

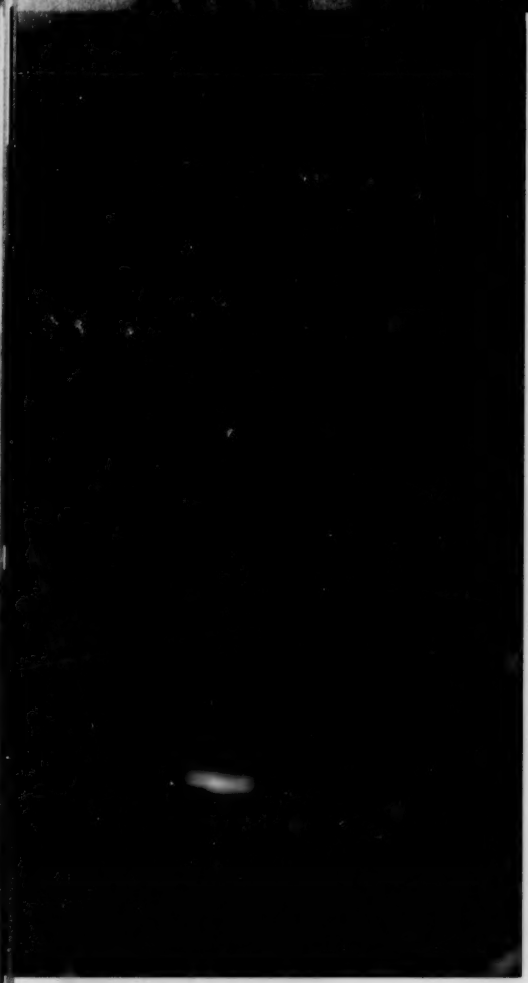
When planning pipeline construction, the least invasive procedures should always be given first consideration.

Concerns can be largely addressed through careful pre-development planning and implementation of appropriate construction and reclamation methods.

Routing options

Pipelines should be preferentially routed through existing disturbed lands, especially rights-of-way (RoWs), or areas of tame pasture or cultivation. Locating a pipeline on native prairie should be the last resort. When it is necessary to develop a new route, the environmental sensitivities of several alternatives should be weighed, and the route causing the least impact chosen.



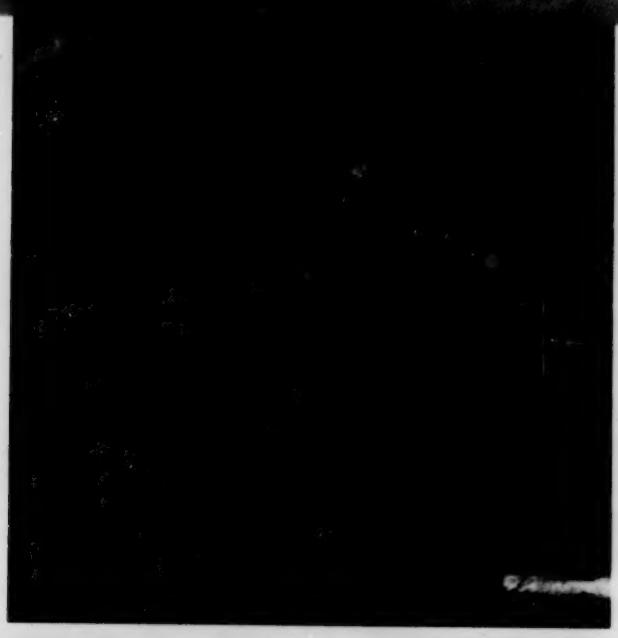


Paralleling old lines

Planning pipeline routes along existing corridors is usually preferred unless the existing pipeline or access road contains rare plant or animal species or crosses sensitive terrain that should not be re-disturbed. Overlapping of old routes seeded to invasive agronomic species like smooth brome or crested wheat grass should also be avoided unless a program to remove the undesirable plants is undertaken.

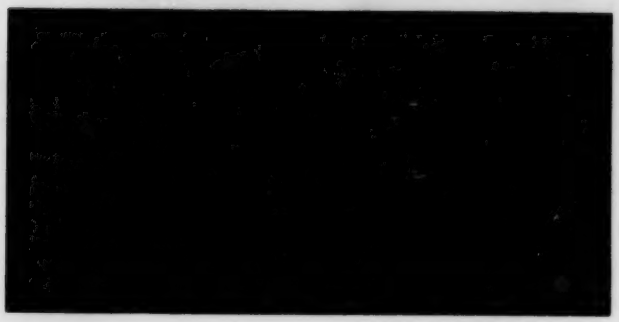
Surveys

Surveys of landscapes, soils, vegetation (including weeds and rare plants), wildlife and historical resources are usually conducted for larger or longer pipelines. The Alberta Natural Heritage Information Centre (ANHIC: www.gov.ab.ca/env/parks/anhic/anhic.html) database is a valuable source of information on rare plants (and other elements) in the province and can be used as a tool to identify areas of concern. The *Listing of Significant Historical Sites and Areas* should also be reviewed to determine if any designated historic sites or resources are situated within the proposed RoW. If sensitive features are identified (e.g., coulees, wetlands, river benches and breaks, dry lake-beds and riparian areas, significant historical resources), the route is modified to avoid these areas. If avoidance is impossible, mitigative strategies are developed in consultation with land managers.



Pipeline construction involves all construction and reclamation activities associated with the placement of pipe in the ground.

Choice of appropriate techniques for a particular job should be based on an evaluation of soil (texture, depth, rocks, moisture and chemical characteristics), vegetation (type, sod thickness, range condition), weather and season, protection of other resources (wildlife, historical), available machinery, safety, project size and length. When future expansion is likely, several pipes can be installed in a common trench, eliminating the need to re-disturb the area at a later date.



The timeframe associated with pipeline construction is short. It is important that soil stripping operations are followed quickly by trenching and placement of pipe to minimize the danger of wind erosion in the dry prairie environment. Access for landowners, livestock and wildlife across the pipeline right-of-way during construction can be assisted by carefully placed trench plugs and breaks in stored topsoil, spoil materials and strung pipe. Pre-construction environmental training sessions are recommended for all personnel to identify both standard operating practice and any special issues associated with the particular project (e.g., rattlesnake protection).

The key to soil handling for pipeline projects is to disturb the smallest amount of area to get the pipeline in the ground.

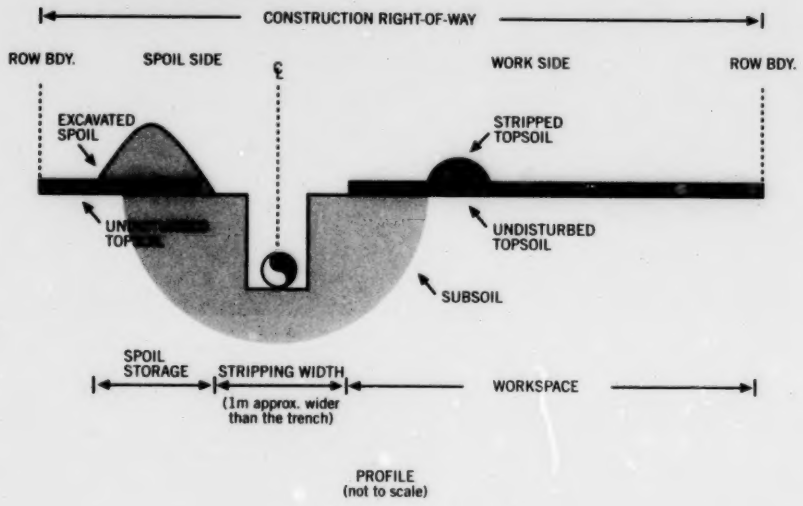
Soil stripping progressions

When constructing pipelines, a balance is needed between minimizing the area of disturbance vs. minimizing the impact of disturbance. For example, if the weather is unsettled, it may be better to strip more topsoil (which increases the area of disturbance) to prevent rutting (which would increase the impact of disturbance). Generally wider areas are stripped when topography is rough, when soils are deeper or sandier, when soil moisture is higher or the weather is poor and when special circumstances such as road, stream or railway crossings, side bends or crossings with other pipelines are encountered. Proposed methods should be discussed with the appropriate land manager. It is also extremely important to have accurate drawings of soil stripping procedures for construction personnel. Trench widths are usually slightly bigger than pipe size to allow soil to get back under the pipe. Larger trenches are required when soils are sandy because the walls tend to slough. Back-hoes are often used for trenching, however, wheel ditchers can be used to construct trenches up to 30 cm (12 inches) wide.

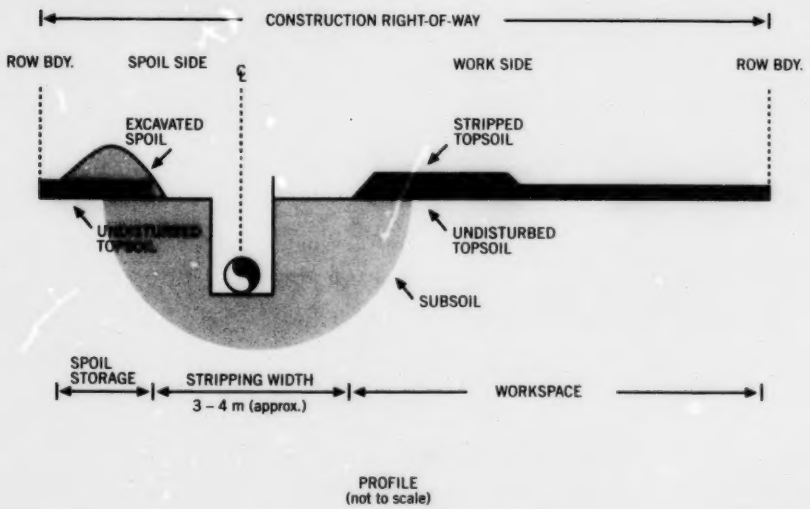
Ploughing in pipelines

Ploughing in means that there is no open excavation, just vertical soil displacement. Small diameter pipelines (<10 cm or 4 inch) can usually be ploughed in, although some bigger lines (<15 cm or 6 inch) are being installed this way. If this is done carefully in the summer, disturbance is minimal with only cracks visible in the sod layer. In a prairie environment, large rocks, wet or frozen soils and complex topography may limit the use of this procedure. In the winter, soils may need to be stripped over the ditchline with a frozen soil stripper. The technique is not suitable for installation of high pressure lines.

Trenchline Stripping



Blade Width



Topsoil Stripping

The salvage of topsoil by stripping is required for installation of most pipelines. Trenchline or blade width stripping are used to protect topsoil resources while still minimizing the surface disturbance associated with the installation of pipelines. Trenchline stripping involves removal of topsoil over the trench width only, and is most suited to low-relief terrain and stable soil conditions. As topography becomes more complex or where there is a risk of sloughing of topsoil into the trench (e.g., sandy soils), blade width stripping should be used. This involves the stripping of the trench line plus an additional width as is appropriate for the site-specific conditions. Larger stripping widths may be needed to accommodate grading in hilly areas, when safety becomes a concern or when environmental conditions deteriorate. Double blade or full width stripping may be required for pipes with a diameter larger than 60 cm (24 inches).

Narrowing the Right-of-Way continued...

"No strip" construction

"No strip" construction for small pipelines (trench <30 cm) involves lifting topsoils and subsoils out together in one operation. Under the right conditions, this can result in less overall disturbance to vegetation.

Roaches

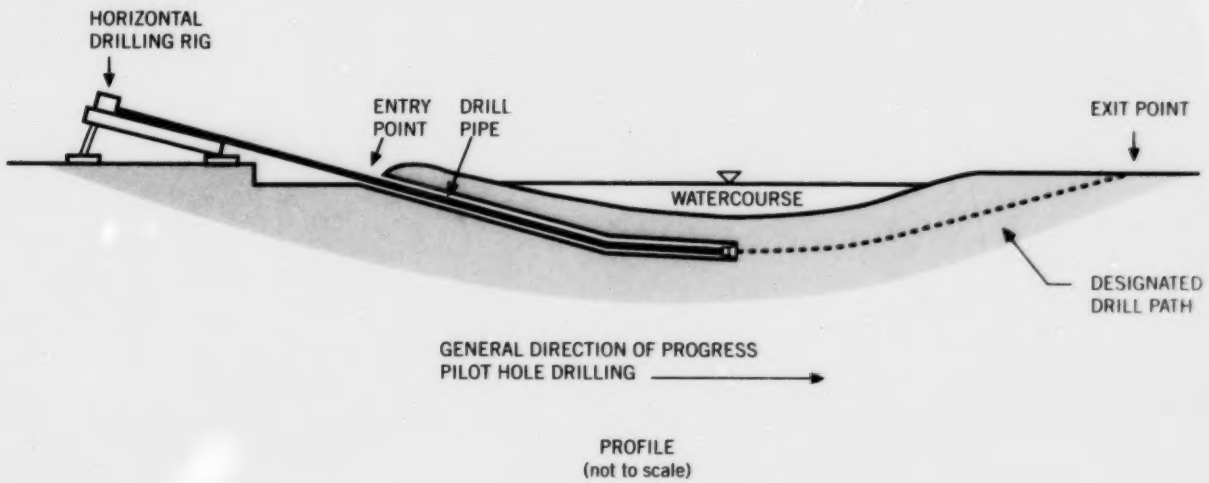
Installed pipelines displace soil. The extra soil has to be feathered out over the pipeline right-of-way so that a raised area (roach) is not left over the pipe. Roaches shed water, producing a very dry environment, that is difficult for plants to grow in. Soil can be placed in a thin layer over adjacent undisturbed prairie sod if necessary. If this is done carefully, with the right equipment, this can result in less overall disturbance to vegetation.

Watercourse Crossings

Boring under prairie watercourses, coulees, and riparian vegetation communities, including the adjacent slopes is preferred to an open cut.

Boring prevents siltation of water and doesn't disturb fish. A geotechnical investigation is usually necessary to determine whether a crossing is suitable for boring. If the area is unstable, an open cut may be required. Suitable erosion control practices must be implemented on steep slopes.

STAGE 1: PILOT HOLE DIRECTIONAL DRILLING



PROFILE
(not to scale)

Reclamation

Once construction or operations cease, reclamation of the disturbed area begins. Reclamation procedures begin the healing process but the reclaimed area may not look identical to the surrounding prairie until many years later. Reclamation "sets the stage" for eventual restoration by "Mother Nature". The ability of the reclaimed prairie area to provide multiple uses and values should be similar to the ability that existed prior to disturbance.

Getting the Site Ready

Recontouring

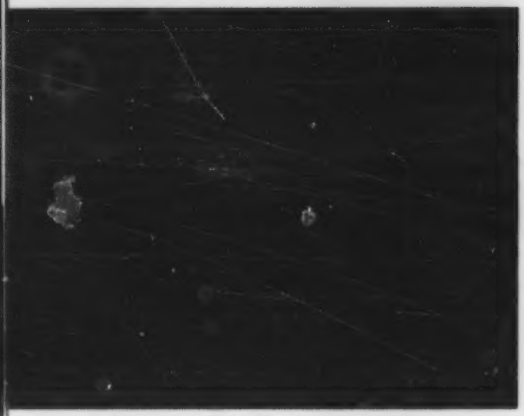
The first step in the reclamation process is to contour the site to fit in with the surrounding landscape. This should be done with subsoil. Topsoil should only be replaced after all contouring is done.

Drainage patterns need to be re-established and erosion control measures taken. On slopes, water bars (trenches) or rock may be placed at strategic locations to slow and direct water movement.

Alleviating compaction

Heavy equipment running repeatedly over subsoil can cause compaction. This can cause problems later when plant roots are not able to grow through such a layer. Usually compaction is relieved with ripping equipment prior to soil replacement. Paratillers can be used to remove ruts, or to relieve compaction in the subsoil after topsoil has been replaced, without mixing soil layers.

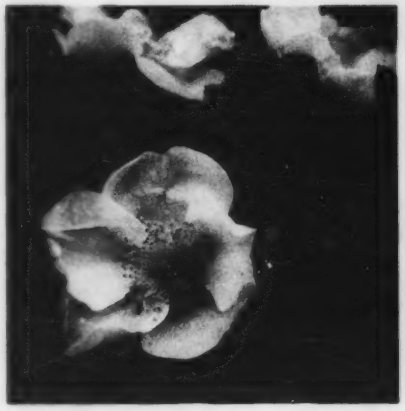
The goal of revegetation on prairie is to re-establish sound ecological function and eventually restore the original range of variability in biological structure and diversity. Revegetating disturbed prairie areas can be a challenging task, particularly in dry years or on problem soils. Revegetation strategies have to consider the needs of the landowner and/or land manager as well as wildlife in the area. The revegetated area often has to fit into existing grazing management plans, for example.



When oil and gas development started on the prairies, wellsites and pipelines were not revegetated. These sites often look very similar to adjacent undisturbed prairie today. Then from the mid 1930s until the early 1990s, introduced agronomic forages such as crested wheat grass, smooth brome and timothy were used in revegetation. These plants cause difficulty as patches on the prairie landscape. Crested wheat grass, for example, matures much earlier than the surrounding native grasses. By the time cattle are turned out to graze in June, the crested wheat grass is too mature for the animals to eat. In addition, these plants are very competitive and seem to exclude native plants from reclaimed sites. Aesthetically, the crested wheat grass doesn't fit in.

Today, prairie sites are seeded to native grasses. Native species must be seeded on publicly owned prairie land disturbed after January 1, 1993, or prior to that date if required by lease conditions or in an approval issued by Alberta Environment (see Alberta Environment's Information Letter (IL) 01-6).

As more species become commercially available, revegetation mixes will be better matched to the plant species in the landscape. Alberta has over 2000 native plant species but only a handful are currently available for revegetation. The Alberta Native Plant Council has a source list of plants and suppliers on their web site: www.anpc.ab.ca.



Seed analysis

When reseeding prairie areas, it is extremely important to ensure that seed is free of persistent weeds and invasive introduced species. The best safeguard is to request a Seed Analysis Certificate from the seed supplier for each native seed lot (prior to mixing). This certificate should be examined prior to purchase to ensure that the seed lot does not contain any species of concern. Generally, annual non-native weeds are not a concern since these are already present in the seedbank on most prairie reclamation sites and do not cause serious problems. A notable exception is downy brome. Check with a local agricultural fieldman for more information about weeds of concern in the area. For a listing of problem agronomic species not allowed on public land, consult Public Lands Update IND 2000–2.

Seed mixes

The first step in designing a seed mix is to consult with a qualified vegetation specialist who has experience in designing and using native seed mixes. It is important to find out what native plants grow near the disturbed site and then to determine if they are available. A variety of plants with different growth forms should be included in a mix. *The Native Plant Revegetation Guidelines for Alberta* (www.agric.gov.ab.ca/publiclands/nprg/) can be consulted for help and for lists of commercially available seed for different areas.

It is important to consider how plants may interact with each other. Some plants are very competitive and their proportion in the mix should be reduced (e.g., native wheat grass cultivars). It is also critical to find out where seed originally came from. Seed whose genetic origin is from too far away (e.g., Europe or the southern United States) may not perform very well. To ensure the right materials arrive at the right time, give the supplier as much lead time as possible.

"The first step in designing a seed mix is to consult with a qualified vegetation specialist who has experience in designing and using native seed mixes"

Seeding rates

Determining seeding rates (the number of seeds per unit area) is not an exact science due to the tremendous variability from species to species in seed size and shape, performance, and differences in seeding and growing conditions. It is very important to consult with experienced vegetation specialists to determine suitable seeding rates. There is a tendency to over seed resulting in stands that quickly become too thick and rank. Drill seeded rates of 10 to 12 kg/ha are more than adequate to provide an adequate vegetation cover on most sites. Lower rates (e.g., 6 to 8 kg/ha) are suitable for sites where erosion potential is low and ingress of native plants from surrounding areas is desired.

Seeding equipment

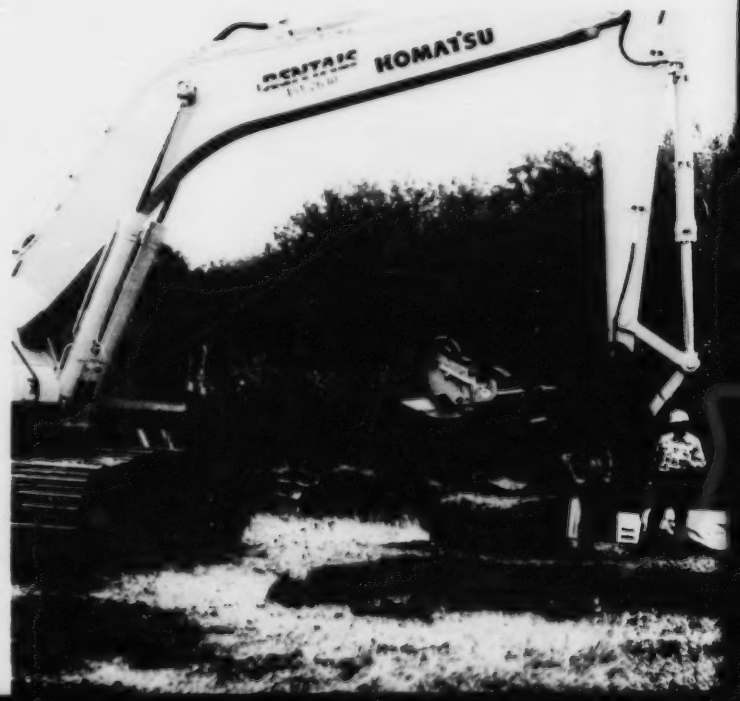
Special equipment is required for seeding native species due to tremendous variability in seed size and shape. No till rangeland drills such as Truax or Great Plains are often used, and should be calibrated several times a day to ensure proper delivery of seed. The Kinsella accuroller is another useful piece of equipment that broadcasts the seed and then rolls it into the ground in a waffle-like pattern. This has the added advantage of creating better conditions at ground level for seed germination. It also places smaller seeds (e.g., June grass) closer to the soil surface where they have more chance of germinating.

Natural recovery

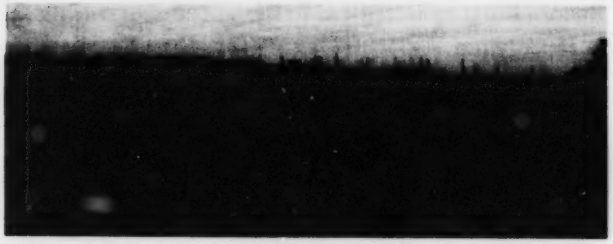
Natural recovery (no seeding) is an appropriate option in some situations. It can be used where the disturbance is small and located away from problem weed sources. The condition of the prairie around the site should be good (lots of seed) and potential for erosion low. Annual weeds are dominant on natural recovery sites for the first several years, which often provides erosion control. These can be mowed if they are too thick. Weeds will start to disappear as the native perennial plants re-establish. Annual crops (e.g., durum wheat, flax) can be seeded at half the normal rate to provide interim erosion control.

Sod salvage

Prairie sod has to be in good condition and thick enough to stay intact when it is cut. If sod salvage is done during the spring or summer, the construction phase has to be short (i.e., a few days), otherwise the sod dries out and the plants die. In the fall, the storage time can be longer (e.g., a few weeks), since the plants are dormant. Salvaged sod should be protected with filter cloth (preferably white to reflect heat). Although the sod salvage technique is time consuming and expensive, it can be useful in specific situations where keeping the original vegetation is very important and the construction schedule allows for it.



Livestock access to newly reclaimed areas may result in overgrazing of vegetation and damage to soils. Reclaimed areas should be protected from grazing during the first year of vegetation establishment.

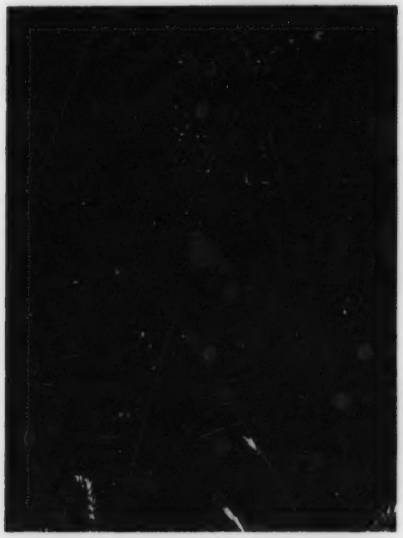


Good communication with land managers is needed to develop an appropriate livestock management strategy. Wellsites on the prairie are usually fenced to keep cattle out. Cattle management along pipelines is variable. Sometimes it is possible to change cattle rotations so that cattle do not graze the fields that the pipeline runs through the first year following revegetation. In other cases, temporary electric fencing keeps animals out.

Location of salt and water well away from reclamation sites also helps to minimize cattle impacts once they are allowed access. It is important not to leave fences up too long. In particular, areas seeded to native grasses need to be lightly to moderately grazed to keep the stands healthy and productive. Reclamation is considered successful only if the site can withstand normal grazing pressure.

Record Keeping

Record keeping is critical to the success of any reclamation/revegetation program. It helps to manage the specific site and assists with the planning and preparation for future disturbances. The following information should be collected:



- **topsoils** – where they came from, storage times, stockpiling methods (including whether they were planted in storage and with what) and replacement depths.
- **site preparation** – what was done, what equipment was used and when each task was carried out.
- **plants and seeds** – type of plant material (scientific names), suppliers, genetic sources, seed analysis certificates, seeding rates and planting densities.
- **other techniques used** – ripping, paratilling, mulching, fertilizing and fencing.
- **management and mitigation activities** and whether they were successful (e.g., rare plants).
- **dates** when each activity was done.
- **maps** indicating where each activity was carried out.

"Record keeping is critical to the success of any reclamation/revegetation program."

Reclamation requirements are not identical for all reclamation sites in Alberta. Site age determines the level that should be used. Newer sites must meet more rigorous standards than older sites.

The criteria for reclamation vary geographically within the province, and with land use. Generally, to determine reclamation success, the condition of landscape, soils and vegetation of the reclaimed area is compared to the condition of the site before construction (where this information is available) or to the condition of similar sites in the immediate area. The reclaimed site must be able to sustain plant growth similar to pre-disturbance growth, controls or agreed upon (in writing) targets.

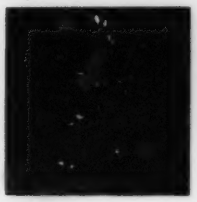
The revegetated area must be able to prevent wind and water erosion, unless erosion is a normal part of the landscape (e.g., sand dunes). The minimum level of acceptable ground cover is site specific and varies according to soil type/texture, plant community, wind, precipitation and slope. Plants on revegetated areas should be healthy, both above and below ground and be able to sustain grazing pressure. There should not be any restricted or noxious weeds on the site.

On sites seeded after January 1, 1993 it is expected that the integrity of native plant communities be maintained and meet land use objectives. Invasive agronomic species (e.g., crested wheat grass, smooth brome, timothy) should not be present. If the reclaimed area is part of a grazing operation, plants should be compatible with plant species offsite, (i.e., be able to be grazed at the same time).

Case Study:

Oil and Gas Development on Providence Ranche

Information for this case study was provided by Marilyn Neville, AXYS Environmental Consulting Ltd., with the permission of the landowner, Hamish Kerfoot, and the company, Olympia Energy Inc.



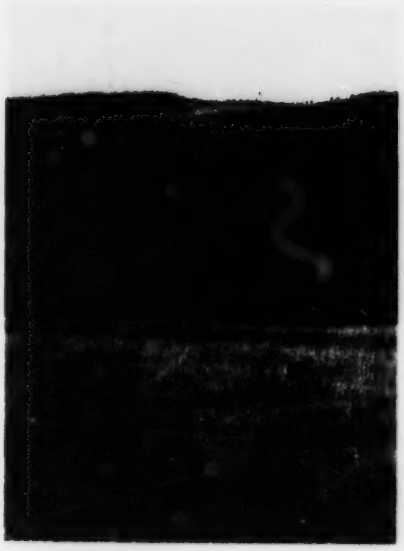
Industry, government agencies and landowners are working together more than ever to try to conserve remaining prairie landscapes. What follows is an example of what can be accomplished when cooperation is at its best. Providence Ranche is located in the Wildcat Hills, approximately 12 kilometres north and west of the town of Cochrane Alberta. Providence Ranche is private land, owned and operated by the Kerfoot family of Cochrane, as a sustainable ranching operation for over 100 years.

In October of 1997, the Kerfoot family decided to protect the ecological integrity of the ranch against increasing pressure from acreage developments by signing a conservation agreement with the Nature Conservancy of Canada. The agreement with the Nature Conservancy allows land uses that ensure the protection, conservation and enhancement of the environment and of natural scenic values. The agreement allows for the continued use of the land for ranching purposes. Oil and gas development is only allowed under very stringent conditions. Other acceptable uses include recreation, environmental education and use for scientific studies.

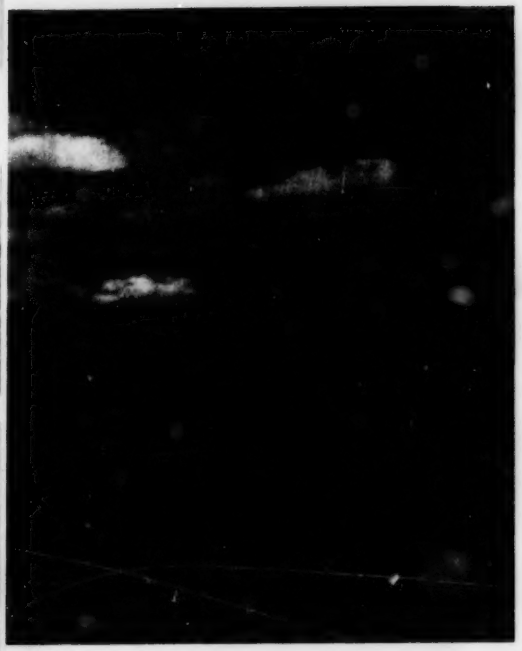
The Nature Conservancy has set out Property Management Principles for these land uses. Olympia Energy Inc., (Olympia), has used the Property Management Principles throughout the development design. At the request of Mr. Hamish Kerfoot, AXYS Environmental Consulting Ltd., (AXYS), was contracted by Olympia to provide environmental assessment and design, and onsite inspection throughout each phase of the development. Joint field visits were also conducted with Alberta Environment staff.

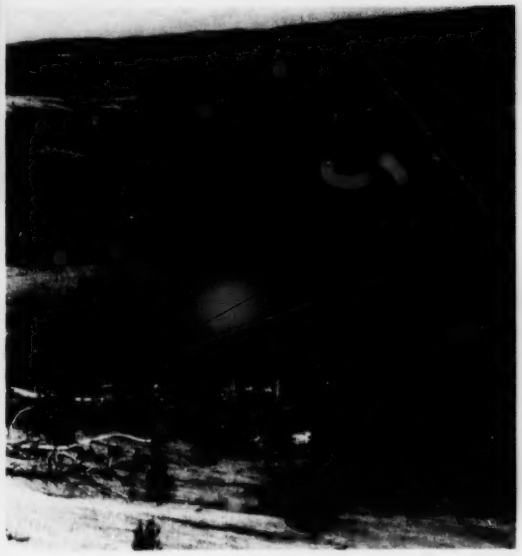
Vegetation

The Kerfoot property is situated where the Foothills Natural Region meets the Parkland Natural Region. The portion of the ranch affected by the Olympia Energy development is primarily a valley bottom, surrounded by steep slopes covered with mature Douglas fir and white spruce forest to the west. To the east, the steep slopes are covered with native rough fescue grasslands and aspen, with limber pine growing in the rocky ridge tops.



The range is in good to excellent range condition. Dominant plant species in undisturbed grasslands are Kentucky bluegrass, rough fescue, and Parry's oat grass. In previously disturbed grasslands, there is a larger amount of Kentucky bluegrass in the stand. Timothy and smooth brome, introduced grasses, are also dominant species.





Development Description

In November of 1998, Olympia reached an agreement with the Kerfoot family to drill an exploratory sweet natural gas well. At the completion of drilling, well test results showed substantial reserves. Olympia then negotiated with the Kerfoot family to expand drilling activity. In February of 1999, AXYS was contracted to assist Olympia with environmental assessment and design for two additional well sites, access trails and associated pipelines.

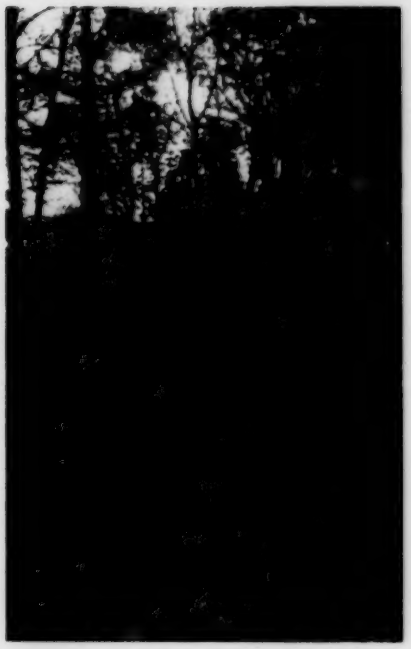
Minimizing the disturbance to the native plant communities and to the overall integrity of the ranch were the primary goals in locating suitable wellsites, access trails and pipelines. Some of the measures taken to achieve this goal include:

- Horizontal directional drilling techniques were used by Olympia to access gas reserves located under steep, naturally vegetated terrain, from well-sites located in the valley bottom.
- Existing access trails were used to get to the wellsites and for pipeline routing. Where necessary, trails were upgraded within a ten metre or less roadway with a minimum grade.
- Detailed pre-construction environmental assessments and environmental protection planning were completed prior to entry.
- There was onsite environmental inspection through all phases of the development. Pat Trautman (Olympia energy) closely supervised all construction activity.

During 1999 two wells were drilled from surface lease locations, located on previously disturbed, improved pasture located in the valley bottom. At the end of 1999, the development was completed. The wellsites were reclaimed for the production phase, the access trail upgraded and reclaimed, and the pipelines reclaimed and revegetated.

In February of 2000, Olympia entered into negotiations with the landowner to drill additional downhole locations from the existing surface lease locations, and to construct a compressor station to improve the drawdown from the reserve. The existing surface leases were used for the construction, with

small extensions to accommodate the drilling rig. The site for the compressor station was chosen to minimize impacts on affected neighbouring properties and the visual impact to the ranch. A central separator unit was installed at the main compressor station located several kilometres south of the Kerfoot property. This eliminated the unpleasant odour that had surrounded each of the wellsites. Again Mr. Kerfoot worked with Olympia and AXYS to ensure the environmental design was consistent with the high standards previously set. By December of 2000, the next phase of development was complete.



Specific Construction and Reclamation Strategies

Several strategies were employed to minimize the impact of the development on vegetation in the project area:

- Minimal width stripping techniques were used for construction,
- Clearing of old conifers was minimized and special pipeline installation measures used to narrow the RoW through these areas,
- Soils were stored on top of unstripped vegetation,
- Traffic on vegetated areas was closely supervised and limited,
- Where stripping was required, soil layers (horizons) were carefully separated.

The goals of the revegetation program are to provide sufficient ground cover and distribution of plants to provide erosion control and to allow natural plant community development to take place. Two seed mixes were designed; one for use in primarily native fescue grassland, a second for previously disturbed grasslands, where Kentucky bluegrass and timothy were prominent. One portion of a pipeline right-of-way was also reclaimed as a natural recovery area, with no reclamation seed being applied.

Monitoring

The goal at the time of final reclamation is to restore the disturbances to the original natural ecosystem function and structure over time. To accomplish this goal it must be remembered that climate and time play major roles in achieving reclamation success. As well, reclamation science is constantly evolving. During the last ten years, new construction methods have been

developed to minimize the impact of developments. The process of revegetation using native plant material has evolved to a level where it is practical and cost effective. Studies funded and conducted by the oil and gas industry are largely responsible for the advancement of reclamation science. Monitoring has been key to evaluating new procedures.
Hamish Kerfoot requested, and Olympia agreed to, the commitment for environmental monitoring to be specifically included in all Environmental Protection Plans. The monitoring program is conducted for three full growing seasons following each stage of the Olympia development. The program designed for Olympia is simple and comprehensive. There are two main components:

- **Qualitative monitoring** in which the assessor is looking for evidence of erosion, contamination, soil and water quality issues, and the presence of weeds. All these factors can affect reclamation success, if remedial action is not taken.
- **Quantitative monitoring** in which the assessor is recording the actual plant species composition at permanently marked locations to ensure a positive trend toward establishment of the original plant community.

The monitoring program has established permanent plots on both wellsites and pipeline rights-of-way (RoWs). Plots have been established to represent both seed mixes, the natural recovery area and an area where soil was stored directly on vegetation during construction. A checklist for the qualitative monitoring is used to identify environmental concerns. The following environmental concerns were identified as important to this project:

- Wind erosion
- Erosion due to surface runoff
- Downslope erosion on cut and fill slopes
- Erosion causing mass movement
- Health of unstripped vegetation
- Soil compaction
- Presence of soil contaminants
- Blocked surface drainage
- Weeds and undesirable vegetation

- Qualitative revegetation success
- Visible siltation of drainages or wetlands
- Impact of grazing livestock on revegetation success
- Subsidence over pipeline trench or access trail

Vegetation species composition and percent plant cover are used as the key indicators of reclamation progress. Over several years they will show whether seeded native species are allowing recolonization by other species from replaced soils and from the surrounding area. These measurements will also show how much of the plant material is weedy and whether weeds are persisting.

Early Monitoring Results (2000)

■ **Qualitative Monitoring**

Very few problems were noted following the qualitative monitoring inspection. There was little or no erosion noted. There was no evidence of soil compaction or soil contaminants. A few areas with blocked surface drainage were noted, and were remedied in the spring of 2001. Gravel was added along access roads in areas where soft spots were noted. Annual nuisance weeds were controlled with mowing prior to seed set. Minor amounts of noxious weeds, Canada thistle and toadflax, were controlled with repeated hand picking or mowing.

■ **Vegetation Monitoring**

All eight species represented in the two seed mixes were observed growing in the disturbance with the exception of mountain brome and streambank wheatgrass. The wheatgrass may be present but misidentified as slender wheatgrass in its non-flowering state.

The natural recovery site has an average percent cover value of 50%, arising entirely from the existing seed and propagules bank. The most prominent species on the right-of-way are Kentucky bluegrass and dandelion. Dandelions (non-native) are present in the undisturbed areas as well, forming 4% of the ground cover. Rough fescue (native) and awned wheatgrass (native) are also re-establishing on the natural recovery site.

Areas with lighter grazing pressure and less timothy in the off RoW vegetation have more species from the seed mix visible. Wellsite areas, which are all fenced, also have a greater variety of grass species re-establishing on the disturbance. However, they also have more weed establishment. Mowing has been undertaken as a control measure on two wellsites. Canada thistle is establishing on the disturbance in many areas. Thistles are plentiful off site in many areas on the property. Other weeds are not generally a problem.

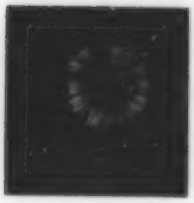
■ **Wildlife Monitoring**

Providence Ranche provides rich and diverse habitat for a wide variety of montane, parkland and grassland wildlife species. Wildlife surveys were conducted for each phase of the Olympia development. Fine-tuning of well site locations, access trails, pipeline rights-of-way and the location of the compressor station were made to minimize the impact to wildlife habitat. Construction and drilling activities were scheduled to minimize the impact during sensitive breeding seasons.

Olympia production personnel have had the opportunity to observe considerable wildlife activity during the development and production phase. AXYS has encouraged the documentation of wildlife sightings around the facilities. These wildlife observations are valuable to monitor the response of wildlife to the facilities and to the increased activity in the area. Other interested people, such as the members of the Kerfoot family, and the Calgary Field Naturalists who conduct annual educational field trips to the area, are also encouraged to record their wildlife observations in the development area.

This case study shows how industry, landowners and regulators can effectively cooperate to ensure that oil and gas development happens in a manner that protects sensitive landscapes and minimizes impacts to humans, wildlife, soils and vegetation. In time, the footprint of this activity on the landscape should be invisible.

Photo Credits



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